PATENT SPECIFICATION

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(19)

(54) IMPROVEMENTS IN OR RELATING TO POSITION SENSORS FOR DISPLAYS

(71) I, SECRETARY OF STATE FOR DEFENCE, London, do hereby declare this invention for which I pray a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to position sensor apparatus for deriving co-ordinate signals to represent the co-ordinates of any selected point on a display.

According to the present invention, apparatus for generating co-ordinate signals representing the co-ordinates of a selected point on a display device includes a substantially rigid sheet mounted on three or four spaced apart force-transducer devices, computing means connected to the outputs of the force-transducer devices for deriving co-ordinate signals representing the co-ordinates of a point of applied force from the relative outputs of the force-transducer devices, and a comparator circuit for determining when the sum of the forces applied to the transducers is less than a predetermined value and providing a warning indication or inhibiting the outputs of the computing means when this occurs.

For instance if there are four transducers at points defined by rectangular co-ordinates (x_1, y_1), (x_2, y_2), (x_3, y_3) and (x_4, y_4) respectively and the forces measured by the four transducers are represented by F_1, F_2, F_3 and F_4 respectively, the electronic computing means should be arranged to compute the quantities

$$X = \frac{F_1x_1 + F_2x_2 + F_3x_3 + F_4x_4}{F_1 + F_2 + F_3 + F_4}$$

and

$$Y = \frac{F_1y_1 + F_2y_2 + F_3y_3 + F_4y_4}{F_1 + F_2 + F_3 + F_4}$$

If the forces F_1, F_2, F_3, F_4 are due to a single force applied at some point between the four transducers, then (X, Y) will be the co-ordinates of this point.

If the transducers are mounted at the corners of a rectangle and two adjacent sides of the rectangle lie on the axes of the co-ordinate system, so that

$$x_1 = x_3 = y_3 = y_4 = O$$

$$y_1 = y_2 = M$$

$$x_2 = x_4 = L$$

the equations for X and Y reduce to the simpler form

$$X = \frac{L(F_2 + F_4)}{F_\Sigma}$$

$$Y = \frac{M(F_1 + F_2)}{F_\Sigma}$$

where $F_\Sigma = F_1 + F_2 + F_3 + F_4$, and the computing means may be merely arranged to calculate these simpler expressions.

Alternatively the rigid sheet may be supported by three transducers at points (O, m), (O, −m) and (L, O) respectively and the computing means arranged to calculate

$$X = \frac{F_3L}{F_\Sigma}$$

and

$$Y = \frac{(F_1 - F_2)m}{F_\Sigma}$$

where $F_\Sigma = F_1 + F_2 + F_3$.

With any of these arrangements any selected point may be indicated by an operator applying mechanical force (normal to the plane of the rigid sheet) at the selected point, and the co-ordinates X and Y then indicated by the computing means will represent the co-ordinates of the selected point.

Preferably the rigid sheet is of a trans-

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parent material so that the apparatus may be placed over a display or a map or diagram or a tabulation, and used to derive co-ordinates of a point on the display or map or diagram or a selected item on the tabulation. However there may be applications for the invention which do not require the sheet to be transparent—a map or diagram etc could be attached to the top surface of the rigid sheet for instance—and therefore transparency should not be considered essential.

The transducers are preferably strain gauge load cells which can be made quite small and the electronic computing circuit may include amplifier circuits for amplifying the signals from each strain gauge load cell, a first summing circuit connected to outputs of two of the amplifier circuits to form the summation $L(F_2+F_4)$, a second summing circuit connected to form the summation $M(F_1+F_2)$, a third summing circuit connected to form the signal representing F_z, a first divider circuit connected to divide the output of the first summing circuit by the output of the third summing circuit, and a second divider circuit connected to divide the output of the second summing circuit by the output of the third summing circuit.

An embodiment of the invention will now be described by way of example only with reference to the accompanying drawings of which:—

Figure 1 shows a co-ordinate sensing apparatus positioned over a cathode ray tube display, and

Figure 2 is a schematic circuit diagram showing one arrangement of an electronic computing circuit used in the apparatus of Figure 1.

In Figure 1 an acrylic sheet 5 is mounted on four strain gauge load cells 1, 2, 3 and 4 arranged at the corners of a rectangle of dimension L×M on the acrylic sheet. Thus if the left-hand side and the base of the rectangle are taken as co-ordinate axes the load cells 1, 2, 3 and 4 will be at points represented by co-ordinate pairs (O, M), (L, M), (O, O) and (L, O) respectively.

The apparatus is placed over the display face of a cathode ray tube display unit indicated generally at 6. Electrical outputs of the load cells 1—4 are connected to an electronic computing circuit 7 which would in practice be mounted within the apparatus though shown separately in the drawing. It has two output lines diagrammatically indicated by references 8 and 9.

In Figure 2 the strain gauge load cells 1, 2, 3 and 4 are shown as bridge circuits whose inputs are energised by an oscillator 10. The outputs of the bridge circuits are connected to amplifying circuits 11, 12, 13 and 14 respectively which produce amplified signals representing the cut of balance currents of the bridge circuits thereby representing the strains produced at the load cells to which they are connected. The electronic computing circuit in this embodiment is a simple analogue computing circuit comprising parts 15 to 21 inclusive with additional parts 22, 23, 24 to inhibit possibly inaccurate representations which could otherwise occur if the applied force is too small to make the dividers in the analogue circuit operate accurately. It includes a first summing circuit 15 connected to receive the outputs of the amplifiers 11 and 12, a second summing circuit 16 connected to receive the outputs of the amplifiers 12 and 14, and a third summing circuit 17 which has four inputs separately connected to receive the outputs of the four amplifiers 11, 12, 13 and 14.

The output of the first summing circuit 15 is connected via a multiplying circuit 18 to one input of a divider circuit 19 and the output of the second summing circuit 16 is connected via a multiplying circuit 20 to one input of a divider circuit 21. The output of the third summing circuit is connected to second inputs of the divider circuits 19 and 21 and also to one input of a comparator circuit 22. The outputs of the divider circuits 19 and 21 are applied to the output lines 9 and 8 respectively. The comparator 22 has a further input connected to a reference voltage source 23 and has an output connected to the energising coil of a relay 24 and to an inhibit line 25. The relay 24 has two normally open contacts which when closed will connect the output lines 8 and 9 to earth.

In operation when it is desired to transmit the x, y co-ordinates of a particular point of interest on the cathode ray tube display to other apparatus (not shown) connected to the output lines 8 and 9, an operator presses the acrylic sheet 5 at a point above the point of interest with his finger or a stylus or a ball-point pen thus applying stresses to the strain gauge load cells 1—4. The relative magnitudes of these stresses will depend upon the point of application of the force applied and can therefore be used to derive the co-ordinates of the point of interest. For example if the force applied to a point whose co-ordinates are X and Y is of magnitude F_z then components of reaction to this force F_1, F_2, F_3 and F_4 will be detected at the transducers 1, 2, 3 and 4 respectively. By elementary mechanics, taking moments about the x and y axes it will be clear that

$$XF_z=(F_2+F_4)L \therefore X=\frac{L(F_2+F_4)}{F_z} \qquad (1)$$

and similarly

$$Y=\frac{M(F_1+F_2)}{F_z} \qquad (2)$$

where $F_z=F_1+F_2+F_3+F_4$.

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The electronic computing circuit 7 has inputs representing the signals F_1, F_2, F_3, R_4; it computes the x and y coordinates according to the equations (1) and (2) above, and applies electrical signals representing these co-ordinates to the output lines 8 and 9.

When a force is applied normal to the acrylic sheet 5 at some point of interest, the load cells 1, 2, 3 and 4 will produce out of balance currents representing the reaction components F_1, F_2, F_3 and F_4 respectively.

The summing circuits 15, 16 and 17 will form outputs representing the summations F_1+F_2, F_2+F_4 and F_z respectively. The multiplier circuit 18 is arranged to multiply the F_1+F_2 signal by a constant proportional to the dimension M and the multiplying circuit 20 is connected to multiply the signal F_2+F_4 by a constant proportional to the dimension L.

The divider circuit 19 produces a signal representing $(F_1+F_2)M/F_z=Y$ and the divider circuit 21 produces a signal representing $(F_2+F_4)L/F_z=X$. If the applied force F_z is below a preset value the comparator circuit 22 will operate the relay 24 to short the x and y coordinate signals to earth and also apply an additional signal representing "no point indicated" via the line 25 to any other associated apparatus. This is necessary because when the divider circuits 19 and 21 receive denominator inputs of less than a predetermined value they may give misleading outputs.

The load cells should be designed to be insensitive to forces in the plane of the acrylic sheet but they should be sensitive enough for the system to work with light finger pressure. Some care should be taken to ensure that the apparatus will be reasonably insensitive to environmental vibration. If the apparatus is to be used in an inclined position as in Figure 1, care should be taken to see that the forces due to the weight of the rigid sheet do not cause significant errors.

Clearly many variations or modifications of such apparatus will now be obvious to persons skilled in the art. The computing circuits may take various alternative forms, some of them appropriate to different dispositions of the load cells about the working area within which points are to be selected and indicated. If only three transducers are used the apparatus will need fewer parts but may have to be made larger to cover a given working area. Digital computing circuits could be used if the transducer outputs are provided in or converted to digital form.

WHAT I CLAIM IS:—

1. Apparatus for generating co-ordinate signals to represent the co-ordinates of any selected point on a display device, including a substantially rigid sheet mounted on three or four spaced apart force-transducer devices, computing means connected to the outputs of the force-transducer devices for deriving co-ordinate signals representing the co-ordinates of a force applied at the selected point from the relative outputs of the force-transducer devices, and a comparator circuit for determining when the sum of the forces applied to the transducers is less than a predetermined value and providing a warning indication or inhibiting the outputs of the computing means when this occurs.

2. Apparatus as claimed in claim 1 wherein the rigid sheet is supported on four force-transducer devices at points represented by rectangular co-ordinates (x_1, y_1), (x_2, y_2), (x_3, y_3) and (x_4, y_4) respectively and the computing means is arranged to produce co-ordinate signals X, Y given by

$$X=\frac{F_1x_1+F_2x_2+F_3x_3+F_4x_4}{F_1+F_2+F_3+F_4}$$

$$Y=\frac{F_1y_1+F_2y_2+F_3y_3+F_4y_4}{F_1+F_2+F_3+F_4}$$

where F_1, F_2, F_3 and F_4 are the values of forces sensed by the four force-transducer devices respectively.

3. Apparatus as claimed in claim 1 wherein the rigid sheet is supported on four force-transducer devices at points represented by rectangular co-ordinates (O, M), (L, M), (O, O), (L, O) and the computing means is arranged to produce co-ordinate signals X, Y given by

$$X=\frac{L(F_2+F_4)}{F_z}$$

$$Y=\frac{M(F_1+F_2)}{F_z}$$

where F_1, F_2, F_3 and F_4 are the values of forces sensed by the four force transducers respectively and $F_z=F_1+F_2+F_3+F_4$.

4. Apparatus as claimed in claim 1 wherein the rigid sheet is supported on three force-transducer devices at points represented by rectangular co-ordinates (O, m), (O, −m) and (L, O) respectively and the computing means is arranged to derive co-ordinate signals given by

$$X=\frac{LF_3}{F_z}$$

and

$$Y=\frac{m(F_1-F_2)}{F_z}$$

where F_1, F_2 and F_3 represent the values sensed by the force transducers respectively and $F_z=F_1+F_2+F_3$.

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5. Apparatus as claimed in any one of the preceding claims wherein the rigid sheet is made of transparent material.

6. Apparatus substantially as hereinbefore described with reference to Figure 1 or Figures 1 and 2 of the accompanying drawings.

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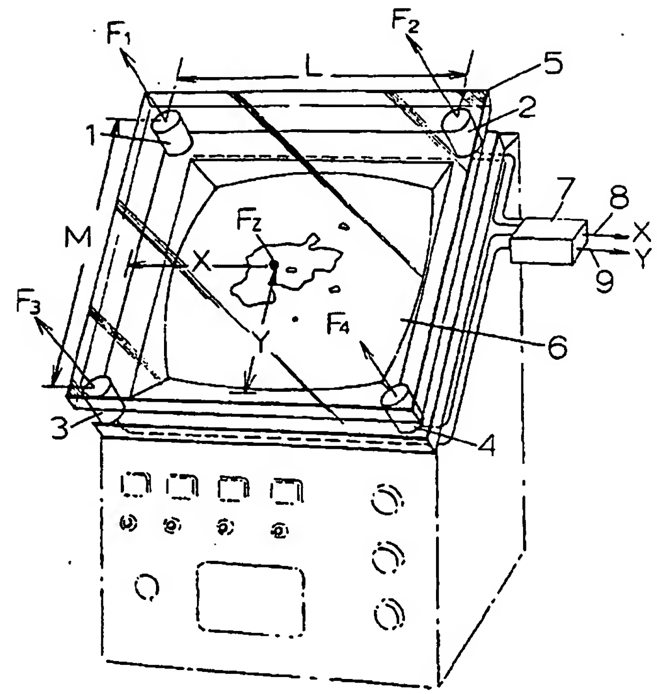

FIG. 1.

1528581 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

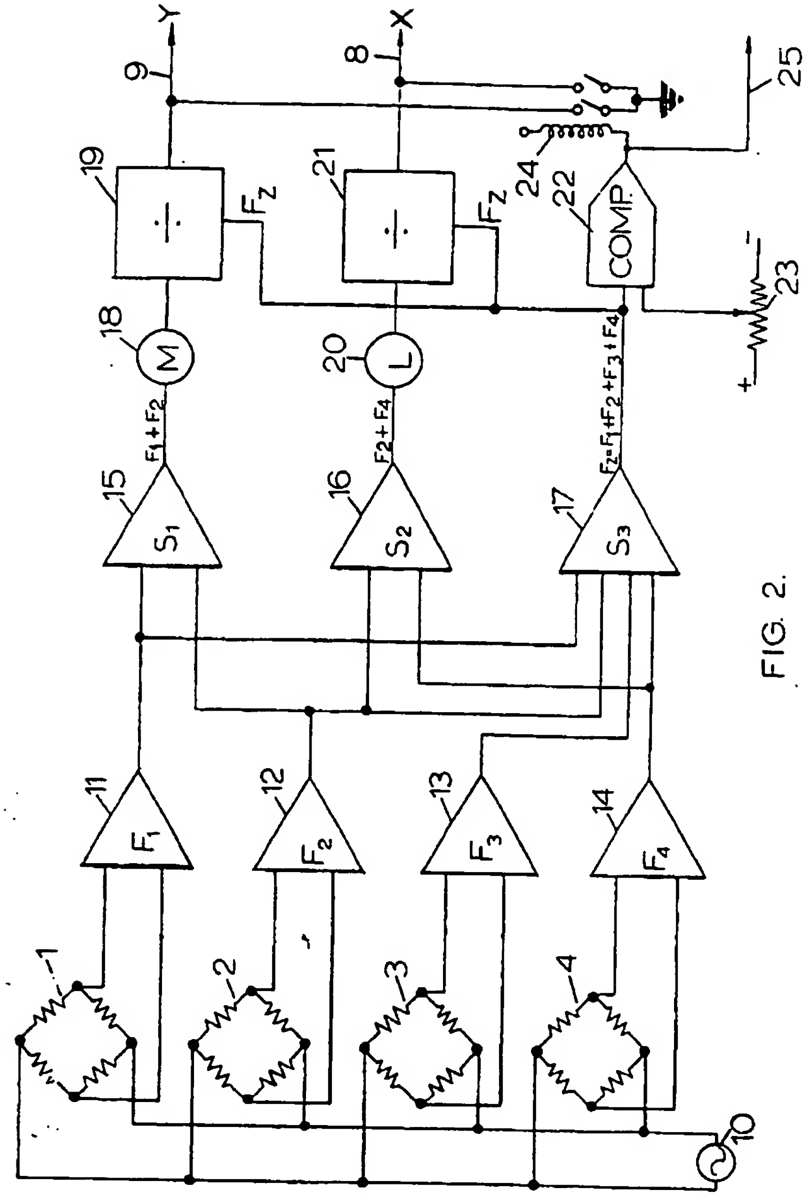

FIG. 2.

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